

Procedural Guideline No. 3-9

Quantitative sampling of sublittoral sediment biotopes and species using remote-operated grabs

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Background

Systematic benthic sampling and analysis originated from investigations of fisheries resources (for example Peterson 1911). Benthic grab sampling techniques have remained essentially the same since that time, although significant developments with respect to positioning equipment and data analysis techniques have occurred. Survey techniques have been developed and adapted to suit a variety of needs, particularly in the oil and gas industry (e.g. rig de-commissioning, pipeline routes), the water industry (outfall discharges), capital and maintenance dredging (spoil disposal), the aggregate industry (licence application) as well as pure research studies and most recently studies designed for the assessment of conservation status within SACs.

This guideline has been adapted from established benthic grab sampling methods described in Holme and McIntyre (1984), Baker and Wolff (1987) and Rees *et al.* (1990). Further consideration has been given to sampling strategies and data analyses from other texts including MAFF (1993), Clarke and Warwick (1994), Ferraro *et al.* (1994), GCSDM (1997), Rumohr (1999), Nikitik (2000) and workshops (Elliott 1997, Worsfold and Dyer 1997).

Purpose

The present guideline has been designed to provide information sufficient to fulfil marine SAC conservation objectives taking into consideration the possible pressures that may exist within or in the vicinity of the SAC. Specific conservation objectives for marine SACs are in preparation and have therefore not been precisely defined. However, the following generic attributes may be met by using benthic grab sampling:

- Determine the distribution of the different biotopes or biotope complexes within a SAC.
- Identify rare, fragile, representative or rich biotopes at the site.
- Measure the species richness in the biotope and/or abundance of key species (rare, fragile, declining, representative) in biotopes.
- Identify and enumerate the quantity of particular species of conservation importance (rare, fragile, declining species – those for which the site is ‘special’).

Specific survey objectives

- Establishing the benthic community composition within and between biotopes.
- Ground-truth mapped areas (established by video or acoustic ground discrimination techniques, e.g. sidescan sonar) occupied by biotopes and biotope complexes).
- Establishing the species which are present in biotopes at a site, including their abundance and biomass within statistical limits.

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- Establishing the species which are present along a gradient of change away from a source of disturbance including their abundance and biomass within statistical limits.

Advantages

The methods:

- are easily employed from a range of boat sizes;
- provide quantitative data on sedentary infaunal and slow moving or sedentary epifaunal species from particulate habitats, which accurately reflect environmental changes;
- provide quantifiable results which are open to statistical analysis and interpretation;
- produce replicable data to a common standard (if using the same sampling gear);
- provide data to which statistical limits may be applied, thus allowing determination of measurable change;
- provide data for certain habitats for which considerable comparative information is available;
- provide data from which biotopes may be quantitatively determined using multivariate analysis outputs.

Disadvantages

- Large variations in community and biotope may occur over a small spatial scale due to natural patchiness, which consequently require intense sampling to account for the variation, due to the 'blind' nature of sample collection.
- Different seabed types require different grab or dredge sampling gear with consequential variation in efficiency.
- The choice of which gear to use relies on preliminary information either in terms of historic data about sediment type, seabed video or remote ground discrimination surveys (e.g. Roxann or sidescan sonar).
- Analysis of sediment samples for fauna can be costly and time consuming.
- Larger and more mobile epifauna tends to be undersampled.
- Data produced for epifauna and infauna may be in different formats.
- Biotope classifications are at present limited for many sediment environments.

Logistics

Equipment

Site location

Maps and charts to the appropriate scale should be obtained, along with as much information, in the form of historic data, as possible (particularly important is sediment characteristics, from which the correct sampling equipment can be determined). Ideally site-specific video should be obtained.²

Sampling equipment

Numerous types of sampling grab are available (see Holme and McIntyre 1984). For the requirements of the present guideline the following are recommended:

- van Veen (lightweight version), appropriate to soft sediments and shallow waters
- Day Grab, appropriate to a range of sediments, from muds through sands to mixed sandy gravel
- Hamon Grab, appropriate to mixtures of sediment, particularly consolidated coarse gravels and cobbles

Consideration may be given to alternative sampling gear, particularly spring-loaded grabs including the Smith-McIntyre or Shipek, which are able to sample coarse substrata and may be deployed from a small vessel. In general these samplers tend to be less easy to handle and take a smaller volume sample. As

² See Procedural Guidelines 3-5 and 3-14.

an alternative to the grab samplers, a dredge (e.g. box dredge) may be employed, particularly if ground truth data only is required. Dredges produce, at best, semi-quantitative data and are not suitable for determining changes in community structure. However, dredges generally sample lower density epifauna more successfully than grab samplers.

Sampling gear and sample storage equipment should be recorded on a checklist. An example checklist is provided in Appendix 1, which contains all equipment likely to be required. Routine cleaning of equipment, using fresh water, will be required after each survey. Maintenance of shackles and any load-bearing cables should be regularly checked.

Vessel and positioning equipment

The size of vessel required should be chosen as appropriate to the conditions in the sampling area and the type of sampling gear to be employed. For example a lightweight, hand-hauled van Veen Grab can be operated from a small open survey vessel (<6m) in sheltered estuarine waters, while the more robust Hamon Grab appropriate to exposed open coastal waters will need to be operated from a substantial vessel (>15m). In all cases where heavy sampling gear is deployed the vessel must be fitted with a suitable power winch and an 'A' frame or gantry (see also Appendix 2).

A differential Geographical Positioning System is essential, with better than 5m accuracy.³

Personnel

Both the Day Grab and van Veen Grab can be operated by two survey staff in addition to a winch operator and skipper. In certain circumstances the van Veen Grab does not need to be winched. The optimum number of survey staff is three to include two for grab deployment and recovery with third for recording and sample processing. The third person may also operate the winch if sufficiently experienced. The Hamon Grab is less easy to handle and requires a third person to assist with deployment and recovery in addition to the skipper and winch operator. At least two of the survey team should be experienced with handling grabs and have experience of sampling and sieving marine invertebrates.

Time of year

The optimum time for field work in inshore waters is May to September. In terms of avoiding recruitment periods the best sampling time is February to May. May is, therefore, the optimum sampling period. Practical constraints may preclude this period so the most important consideration is that repeat surveys should be completed at the same time of year, taking into account predictability of weather conditions.

Method

Field methods

Sampling arrays

A variety of sampling arrays may be employed depending on the objective of the study. An important consideration is the applicability of certain of the statistical procedures that may be required subsequently. The following are examples that are relevant to monitoring SACs, but they do not include all types available:

Random. A random array is plotted using a grid over a map of the survey area, with numbered x and y axes. The location of each of the sites should be determined using pairs of numbers from random number tables. The first number corresponds to the x axis and the second to the y axis. Random surveys are frequently employed if no other data is available at the pilot survey stage. The problem with random arrays is that some areas may be undersampled. To avoid this possibility stratified random selection may be used, which requires some knowledge of the proposed survey area.

Stratified random. This method involves dividing the survey area into discrete sections which are allocated a proportional or weighted number of randomly selected sites. The stratification may be selected on the basis of environmental conditions, such as known biotope or other variables, including water depth, distance from shore, etc. Site selection with stratification is the same as for the random array. The number of sites per stratification should be proportionally related to the total number, generally in terms of area. Weightings may be applied which allow greater numbers of sites to be

3 See Procedural Guideline 6-1.

allocated to more important areas as required.

Systematic grid. A grid may be plotted over a chart or digital copy of the area to be surveyed. This array is generally employed to consider impacts due to known but diffuse pollution sources. The array should cover the full area within which an expected change may occur, with similar but remote areas included as control sites. Sites should be located at the intersection of lines on the grid. The grid need not be square.

Site location

Latitude and longitude (or grid) for sample sites should be determined prior to beginning field work (or should be the same as for sites surveyed in the pilot or previous monitoring survey). When using the GPS make sure that the correct datum is employed, e.g. WGS84 or OSGB, etc. Positioning should be by dGPS with better than 5m accuracy (offset on the vessel should always be noted), with quality control checks taken from known positions and records of signal quality during the survey. See note ³ above

Sample numbers

The number of samples and replicates required is subject to the necessity for achieving an accurate description of the fauna, while taking into account natural variation, which is dependent on the sediment type and environmental conditions. Ideally for pilot surveys a large number of replicates should be collected (6–10), with the optimum number required for repeat surveys calculated after analysis has been completed. In all cases it is better to collect more samples than required, if time allows. However, where costs are an important consideration it is recommended that, at each site, a minimum of 5 replicate samples should be collected in the case of the Day Grab or van Veen. A minimum of four replicates only may be used for the larger Hamon Grab samples (each of which may be up to 20l in volume).

Grab deployment

Full deployment procedures are listed in Appendix 3. The following briefly describes field procedures. At each site the grab should be set down gently, with the winch wire remaining vertical. In the case of deep or fast-moving water this may require additional weights on the grab and maintaining position by motoring into the current or, in exceptional circumstances, anchoring. Site position should be noted at the time the grab sample is taken. Additional notes should be made of the water depth, time (24 hr clock), weather and sea state (see Appendix 4). On retrieval the grab should be placed on the landing table.

On-board processing

The sample should be checked for adequacy. In the case of the Day Grab and van Veen the depth of the sediment at the centre of the grab should be measured. In general a depth of greater than 7cm is required in muds and 5cm in hard sands. Anything less may be retained, but should not be used unless no other sample is available. The Hamon Grab sample should be emptied directly into a box marked with volume gradations. Anything less than 7.0l should be discarded, unless no other sample is available. Records of sample size must be noted.

Where practicable, photographic records should be made of whole samples (only possible when decanted into hoppers in many cases), along with information on surface colour, surface texture (e.g. concretions, presence of mudstone), colour change with depth, smell and presence of H₂S blackened sediments. Consideration should be given to measuring Redox potential, Eh (mV) with a platinum pin electrode, bearing in mind that in coarse sediments it is not possible to achieve stable values. Additional notes covering any aspect of the sample should be made, including dominant fauna, presence of dead shell or single large stones, etc. These additional notes can often prove invaluable in the interpretation of data. Ideally a pro-forma should be prepared to record these details (see Appendix 4 for an example); alternatively information should be noted in a log book.

If sub-sampling is required for metals, organic matter/CHN or other chemicals, these should be collected directly from the undisturbed grab bucket before the sample is decanted into the receiving hopper. Sediment particle size samples may be collected from well-mixed sediments once decanted. Appropriate scoops should be employed depending on the analysis required (metals need plastic scoops, others need stainless steel). In general once samples have been subsampled for granulometric and other analyses, they should not be used for faunal analyses.

The faunal samples should be gently decanted into a receiving hopper (large buckets in the case of Day and van Veen, a fish box for the Hamon). The grab is to be rinsed thoroughly before redeployment. Water should be added gently to the receiving hopper to produce a water sediment suspension. The sample is transferred in small quantities to a sieve in a separate water-filled hopper.

Sieving should be by puddling, with no direct jetting of water on the sieve and ensuring no water over-

tops the sieve. Consideration should be given to two-stage sieving for coarse sediments, to avoid specimen damage, i.e. 5mm initial sieve over a 1mm sieve.

The residue on the sieve should be back washed into pre-labelled specimen containers (mark on main body of pot and indicate job name/number, date and location). Once samples are collected containers should be marked three or four times with site and replicate number. Back washing should be undertaken over a tray or fish box to avoid accidental loss of the sample. The sieve should be checked and cleared of trapped fauna and any sediment impeding the efficiency of the sieve. A waterproof label with site details should also be added to the sample container.

Fix samples in 10% formal saline: this may be undertaken on return to the shore, but in all cases it must be done within 24 hours of collection. The sample containers must be filled with sufficient fixative to completely cover the sediment retained.

Laboratory methods

Preservation and storage of faunal samples

Formalin is added to the faunal samples obtained as soon as possible. Formalin at 40% w/v is added to the seawater already covering the samples until an approximate dilution to 4% w/v is obtained. If unbuffered formalin is used, di-sodium tetraborate (Borax) should be added to the sample at a ratio of 1.5g/l to prevent the leaching of calcium from shell material within the sample.

The above should be taken into account particularly if samples are to be transferred once treated with formalin. Only vehicles with separate driving compartments, or preferably open-backed trucks, are acceptable.

The samples collected should be registered on return to the laboratory in a central record book. Each site is allocated a unique registration number (which should be written on the bucket) and notes on the number of replicates, survey and job number together with date taken, sampler, and who registered the samples, analyses required and other notes are recorded in the book. Grab samples (and dredge samples containing fine material) can be stained with Rose Bengal, which turns animal protein red and aids the sorting process. Very little stain is required for most samples (<0.2g), and over-staining will hinder identification of the samples. Once stain and formalin have been added, samples should be stored in a cool, well-ventilated and secure area. Finally, a check on the labelling of all pots should be made to avoid later confusion.

Sorting, identification and biomass analysis

A national standard method, such as that prepared by the EA (White 1993), with respect to laboratory treatment of biological samples, should be adhered to, although consideration should be given to ongoing developments as part of the best practice review (IECS 1998). In most cases a procedure should be adopted and modified in-house by the organisation undertaking the analysis and should include a clear QA element.

Special note

An important consideration with respect to the objectives of the SAC monitoring requirements is the analysis of epifauna. Many of the existing biotopes identified by the JNCC are based on visually observed epifaunal components. Historically the analysis of particulate environments has been based on infauna, with limited regard for the assessment of the epifauna. Where epifauna has been assessed it tends to be given a presence/absence attribute. Clearly where the data acquired from benthic grabbing surveys are to be used in the context of existing and future biotopes, a numerically accurate assessment of epifauna must be adopted. To overcome this it is possible to employ a numerical abundance estimation based on the SACFOR scale (Jarvis, S in prep.). To allow inclusion of data in further analysis, a numerical equivalence, based on an inverse Log_e transformation, may be applied.

Physico-chemical analysis

Chemical methods are not defined in this series of guidelines but references to numerous techniques can be found in CEFAS (1997). Particle size analysis should be undertaken according to the methods described by Buchanan (1984) for sediments with a substantial proportion greater than 63mm in diameter. Sediments with substantial proportions less than 63mm in diameter may be more effectively analysed by laser diffraction methods. Data should be presented according to JNCC standard format.

Data analysis

Objectives

Reference back to the conservation objectives must be made at this time. The extent to which data analysis is pursued, or even the level of invertebrate identification, is related to the objective. For verification of many of the existing JNCC biotopes (surveyed by video and AGD ground truthing) it is not necessary to undertake in-depth identification and enumeration, as most of the existing biotopes are based on a relatively limited number of dominant species, frequently including evident epifauna. Further particulate-based biotopes, which will be defined in the future, will be based on a wider range of infaunal species and will probably rely on the use of the multivariate analysis described below.

Other objectives require that a measure of evident change in biotopes is made. To achieve this, analytical methods are required, to which statistical limits may be applied to determine acceptable variation.

Procedures

A range of data analyses procedures is available. They are extensively described in Clarke and Warwick (1994), and GCSDM (1993).

An initial consideration will be to verify the biotopes present in the survey area. As indicated above this may be achieved relatively easily by identification of the most characteristic species only. These may then be fitted to known biotopes using Conner (1997). However, greater definition of existing biotopes, development of new biotopes and refinement of existing biotopes will be possible by utilising more advanced analytical procedures. The initial stage to achieve this will be an initial grouping of sites sampled according to faunal similarity. Once site groups have been defined the physical conditions present at the sites may be summarised to provide a habitat description. If sufficient faunal definition is possible a full associated species list may be determined. The techniques most widely accepted in the UK for the definition of faunal assemblages are Bray and Curtis similarity analysis in combination with a hierarchical clustering procedure and ordination by non-parametric Multidimensional Scaling (MDS). These are by no means the only methods; other frequently employed alternatives include TWINSpan and CANOCO (see Clarke and Warwick 1994). Various software packages are available for these analyses including Primer and MVSP.

In terms of monitoring it may be necessary to provide a quantitative comparison based on the faunal assemblage. Having defined the faunal assemblage to be examined, the minimum data analysis should comprise a consideration of number of species, total abundance and biomass. These three 'primary variables' may be used to test year-to-year variation, in terms of percentage difference between years for each variable. In turn these differences can be used to undertake compliance testing against acceptable levels of change. A full explanation and description of these methods is given in MAFF (1993). These methods were originally devised for compliance testing at sea disposal sites, and have been expanded to include wastewater discharges. They can, therefore, be employed to provide a coarse measure of deviation from the *status quo* with limits applied on a site-by-site basis, which may be considered as 'Action Points'.

Where possible the analysis of primary variables should be supported by other univariate (diversity indices and graphical methods) and multivariate analysis techniques (MDS supporting analyses such as ANOSIM and BIOENV), particularly where any deviation from normality is noted (see MAFF 1993). In all cases a broad approach to data analysis should be adopted, without losing sight of the species that contribute to the data sets.

Accuracy testing

The data produced will accurately represent the true communities and biotopes, depending on the heterogeneity of the environment and the number of replicates collected. Inaccuracies can arise due to a range of factors including the possible lack of experience and conscientiousness of workers, both field and laboratory, and their species identification skills. The amount of error or variability likely has been established by tests undertaken under the auspices of the NMBAQC. Participation in the NMBAQC or a similar QC programme will assist in measuring and removing sources of error.

QA/QC

Quality assurance measures should focus on the following areas:

- repeatability of site positioning
- quality and quantity of the sample
- accuracy and traceability of the sample numbering
- accuracy and traceability of sample registration
- accuracy of sample sorting and species identification (participation in NMBAQC)
- repeatability of physical and chemical analyses (UKAS preferably)
- accuracy of data compilation

To assure quality it is recommended that organisations should prepare their own in-house procedures and training records, including, but not limited to, the following aspects of the work:

- records of training and experience of survey personnel
- procedures for handling and use of chemicals
- procedures for handling survey equipment
- procedures for collection of biological material
- records of training and experience of laboratory staff
- procedures for sorting of biological material
- procedures for identifying biological material
- procedures for recording biological and environmental data
- procedures for analysis of biological and environmental data
- records and training (CVs) of data analysts

Data products

Outputs may consist of the following:

- Ground-truth confirmation of biotope in tabulated format. Different levels of definition are possible related to the requirements of the survey for which the ground-truthing has been provided. For example, detailed biotope level outputs in support of video studies, or biotope complex level outputs for sidescan surveys.
- MNCR standard faunal spreadsheet of species at all sites sampled (Excel).
- Summarised environmental conditions.
- Summarised univariate statistics.
- Multivariate outputs including dendrograms of sites and MDS (or similar) ordinations.
- Biotopes derived from groupings of sites based on the multivariate outputs with inclusion of physical data.
- Results of hypothesis testing, using univariate statistics, particularly the primary variables species, abundance and biomass.
- Mapped outputs (in GIS compatible format) of sites, species and biotopes, as required.

Cost and time

Field. Mobilisation and demobilisation will be site-dependent but will be at least one day each. On site it is possible to sample up to 40 times per day using the Day Grab or van Veen. The Hamon Grab is less easy to handle and a maximum of 30 per day is possible. In all cases sampling speed is subject to variation due to water depth, current speed, size of survey area, weather conditions, daylight, etc.

Laboratory. The laboratory time is usually very high, except where simple biotope confirmation is required, which may even be undertaken in the field. Sorting of samples is dependent on the nature of the sediment. Generally sands are very rapidly sorted (15 minutes); muds often take longer due to the large numbers of small specimens (several hours), whereas large consolidated gravel samples, with con

siderable amounts of retained material, may take more than a day. Use of elutriation methods should be considered to speed up the sorting stage. Similarly, the identification stage will vary. Low diversity samples dominated by infauna can be identified in less than one hour, with high diversity muddy gravels, containing many epifauna, taking several days. Consideration should always be given to the additional time taken to complete QC checks and reference collections.

Data analysis. Time taken for data analysis will depend on the extent of the analyses employed. Simple compilation of an Excel spreadsheet including classification using the MCS/Ulster Museum Species Directory codes and full QC checks may take up to two days for a 50-sample/400-species data set. Employing an MDS package is very rapid (<1 day) once the data has been adequately formatted, but a time scale for the interpretation of the outputs is dependent on the complexity of the results and may involve several reruns of the data. Analysis of biomass data is dependant on the information required, which may range from simple year-to-year community biomass change (<1 day) to relatively complex and time-consuming calculation of the productivity of individual populations.

Health and safety

A comprehensive code of safe operating procedures for field work should be drawn up, with particular reference to protective clothing to be worn during sampling and containing operating procedures for potentially dangerous equipment. Risk assessments must be prepared for specific locations where field work is being undertaken. Laboratory safety codes of practice (including COSHH approved methods) must be followed and would be expected to form an integral part of the procedures indicated in the QA/QC section above.

FORMALIN IS EXTREMELY DANGEROUS. IT IS HIGHLY TOXIC AND A CARCINOGEN. IT WILL BURN SKIN ON CONTACT. EXTREME CARE IS NEEDED IN ITS USE ALWAYS.

- Wear protective clothing (such as a fastened lab coat or boiler suit)
- Wear safety spectacles or a full face mask
- Wear protective gloves
- Take great care to avoid inhalation of fumes
- If contact with skin occurs wash thoroughly with water. If spills occur, dilute with plenty of water
- Always wash hands thoroughly after use

Always use formalin in a well-ventilated area, preferably a fume cupboard or outside away from buildings and people.

Examples of safe vessel operating procedures have been included in Appendix 2, along with vessel choice considerations.

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Appendix 1

Example equipment list

Infaunal and epifaunal sampling methods and procedures

Equipment checklist

<i>Activity</i>	<i>Equipment required</i>
Navigation	dGPS (Sercel NR103; NR51; Leica MX412 Professional Differential GPS)
Infaunal sampling	<p>Hamon Grab (either 0.19m² or 0.1m² sampling area)</p> <p>Hamon Grab Table</p> <p>Optional extra Hamon grab bucket – 1 of stainless steel, 1 of galvanised steel vanVeen (light weight version 0.1m²)</p> <p>Day Grab with stainless steel buckets (0.1m²)</p> <p>Day Grab weights and bolts</p> <p>Day Grab safety pin</p> <p>Day Grab landing table and bolts</p> <p>Shipek Grab and stainless steel buckets (0.04m²)</p> <p>Shipek Grab landing tables</p> <p>Shipek Grab loading arms and safety handle</p> <p>2 Shipek Grab weights</p>
Epifaunal sampling	<p>Armoured 1 metre naturalists dredge</p> <p>2 metre Lowestoft beam trawl</p> <p>Scallop dredge</p> <p>Box Anchor Dredge</p>
Additional equipment	<p>Toolbox containing adjustable wrench and spanners to fit grab bolts and landing table bolts</p> <p>2 x 200mm diameter brass sieves of 1mm or 0.5mm sieve aperture with raised plastic surrounds. An optional 5mm sieve may be used in coarse sediments to remove larger material</p> <p>Sample hoppers for catching sample from grabs – may be boxes or waste bins of suitable waterproof construction and adequate volume. Purpose-built hoppers with spouts to decant samples through the sieves may also be employed</p> <p>Deck wash, preferably with a 'shower head'</p> <p>Wash bottles</p> <p>Forceps</p> <p>Scoops (plastic for metals samples, stainless for pesticides and hydrocarbons)</p> <p>Empty plastic boxes for sample storage</p>

<i>Activity</i>	<i>Equipment required</i>
Safety equipment	<p>Life jackets</p> <p>Hard hats</p> <p>Safety footwear (preferably waterproof)</p> <p>Waterproof clothing</p> <p>Thermal clothing</p> <p>First aid kits</p> <p>Antiseptic wipes</p> <p>Thick, protective gloves</p> <p>Sun tan lotion (where applicable)</p>
Consumables	<p>Paper towelling</p> <p>30cm x 45cm plastic bags with white panel for labelling for PSA samples and organic content samples</p> <p>Plastic cable ties for securing bags</p> <p>Faunal containers: a range of plastic containers (buckets or pots of volume suitable for the size of sample to be taken). Normally an assortment of sizes between 1l and 10l are suitable</p> <p>Other jars as appropriate for chemical analysis, e.g. pentane washed glass jars with foil lids for pesticides</p>
Chemicals	<p>Buffered (Borax) 40% w/v Formalin for preservation of faunal samples</p> <p>Rose bengal for staining (as appropriate)</p>
Other	<p>Non-water-based permanent marker pens (black ink)</p> <p>Admiralty chart of the area</p> <p>List of sampling station positions in OSGB Grid or OSGB lat/long</p> <p>Bound survey log book</p> <p>Sample and record sheets</p> <p>Weather sheets</p> <p>Anemometer</p> <p>Mobile phone</p> <p>Camera</p> <p>Log book</p> <p>Food and drink</p>

Appendix 2

Safe working practices on boats

General rules to be observed when working on boats

A weather forecast should be obtained by the person in charge of the work before embarking. This should be obtained from a reputable source (e.g. Meteorological Office or Metfax) with as much detail about wind and sea conditions as possible.

- Access to the vessel must be limited to the crew, survey and anyone sub-contracted to them.
- If the vessel is hired with crew, the responsibility for safety ultimately rests with the operators. However, the team leader should satisfy him/herself that the safety standards are adequate. A risk assessment should be conducted.
- Life jackets must be taken on to the vessel and worn at all times when working.
- Safety footwear must be worn when operating grabs or heavy equipment.
- Safety headgear must be worn when operating grabs or working on a deck with overhead equipment pulleys/blocks, etc.
- Protective gloves (thick rubber) must be worn when handling grabs or cables.
- Footwear must have appropriate soles with good grip.
- Care must be taken when boarding the vessel. If there is a risk of falling into the water (e.g. climbing down a ladder) put life jacket on first. Move around vessel with caution.
- Before handling and operating equipment make sure you are familiar with the appropriate safety guidelines.
- Familiarise yourself with the location of the safety equipment on the vessel, e.g. VHF radio, lifeboat/raft and fire extinguishers.
- Any accidents or incidents must be reported to the person in charge and recorded in the appropriate accident book.
- When sampling, any cuts or grazes on exposed parts of the body should be covered with waterproof plasters/dressings.
- Long hair must be tied back when operating equipment.
- Smoking is forbidden when collecting samples (can also cause contamination).
- Antiseptic wipes will be available and should be used for cleaning hands before eating and drinking.
- The working deck area should be kept as clear as possible, especially areas where equipment is being deployed or retrieved.
- A portable first-aid kit (complete with basic first-aid equipment including emergency eye-wash) must be taken on each survey.

All vessels must be certificated by the MCA to brown code standard. Where such a vessel is not available a suitable vessel may be used in agreement with the client and the MCA. The vessel must be checked **before the survey** to ensure it has the following:

- echo-sounder, radar
- hydraulic winch with adequate length of cable in good condition
- sufficient clearance for the grab at back/side of the boat
- adequate deck space to work on
- skipper with VHF licence and *valid* relevant qualifications
- deck wash
- water (drinking) supply
- power supply – 12v
- position fixing equipment
- adequate space for the number of people working

- safety equipment – life raft, VHF radio, flares, CO² extinguishers, etc.
- toilet (HSE requirement)
- cabin space

To reduce the time taken to carry out the survey, the available times of access to a harbour need to be checked before the survey. The harbourmaster or local fishermen will know at what tidal states a harbour is accessible. Also ensure that there is a suitable place for the loading and unloading of heavy equipment on and off the vessel. Contact the harbourmaster in advance for availability of berths.

Appendix 3

Deployment procedures for grabs

Day Grab operation

General handling

Beware when moving the grab that the firing plates may be pushed up, trapping fingers. Always wear safety footwear for even the smallest move. Only hold in safe areas. No fewer than two people to lift the grab, no fewer than two to handle it when being winched. Ensure safety pin is inserted to hold jaws in position. Always wear thick gloves, safety footwear, life jackets and hard hat when operating grab on boat.

Do not attempt to use grab if weather means it will swing.

Loading

- Tie table to boat for stability.
- Place grab on table and ensure it is secure.
- Slacken cable to close jaws.
- Draw jaws together, raise the bar to enable them to meet and lower bar between the catches. 'Rattle' the bar to ensure a good fit.
- Insert safety pin.
- Ensure safety pin and weights will not interfere with grab operations on the seabed.
- **It is now ready to fire.**

Deploying

- Ensure cables are around pulleys.
- Hold grab by frame only.
- Winch the grab off the table and guide by use of the frame off the side of the boat, ensuring it does not fire prematurely.
- Remove the pin.
- Lower the grab slowly until clear of the boat.

Retrieval

- If the grab is swinging wildly on retrieval, drop it back in to the water until the boat is stable. Do not attempt to land it.
- Hold grab by frame only, keeping fingers clear of the danger area where firing mechanism will rise.
- Lower onto the table.
- Once on the table, ensure it is stable before lifting buckets to release the contents into a hopper. It is possible to knock the buckets against the trigger bar to reduce wash water requirements.
- Sample taken should be discarded if (a) sediment has been obviously disturbed due to wash out on winching up from the seabed; or (b) the grab bucket is less than half full. If the jaws of the bucket are held open because of stones etc., the sample should only be discarded if points (a) and/or (b) apply. Notes on sample volumes should be made on the log sheet/book.
- Sub-sampling should be undertaken before the sample is decanted into the hopper.

Hamon Grab operation

General handling

- The grab must be lifted with a winch, crane or fork-lift vehicle (approx. wt. 350kg although reduced scale versions are also available)

- Landing table is designed to be welded to the deck of the survey vessel. Grab must not be used unless this is so, or the table is secured by some other means (bolting, etc.).

Loading

- Ensure that there are three people available to carry out the operation in addition to a winch operator.
- Ensure safety catch is engaged as tension on the cable for winching off boat is applied.

Deploying

Winch off the boat with two people ensuring the grab is guided over the stern by the frame.

Retrieval

If the grab is swinging wildly on retrieval, drop it back into the water until the boat is stable. **DO NOT ATTEMPT TO LAND IT.**

When boat is stable, grab is winched up the stern until the chain loops on the frame are accessible. If the orientation of the grab frame is incorrect, one person should hold the frame and turn the grab until the chain loops are accessible. The other two staff can then attach the hauling lines to the chain loops on the frame. The hauling lines are then manually pulled taut and the winching on to the boat resumed, maintaining the tension on the hauling lines until the grab is safely lowered on to the table. The hauling lines can then be safely removed. Place hopper underneath before opening grab.

Sample taken should be discarded if; (a) sediment has been obviously disturbed due to wash out on winching up from the seabed; or (b) the grab bucket is less than half full. If the jaws of the bucket are held open because of stones etc., the sample should only be discarded if points (a) and/or (b) apply. Notes on sample volumes should be made in the log book. A pre-marked hopper is used to estimate the volume of sediment collected within the grab bucket. Sub-samples from homogenised sediment are taken if required.

Appendix 4

Example pro-forma for on-site records

Sample recording sheets are being developed for the National Marine Monitoring Programme and will be issued with the next revision of the *Green Book* in March 2001. They can be downloaded from the *Green Book* internet site.⁴

4 <http://www.marlab.ac.uk/greenbook/GREEN.htm>